News about the high pressure mineralogy in Tissint (olivine-phyric shergottite): (Ferro-) Periclase and nano-micro Diamonds

V.H.Hoffmann[1], M. Kaliwoda[1,2], M. Junge[1,2], F.Hentschel[2], W.W. Schmahl[1,2]
[1]*Faculty of Geosciences, Department of Geo- and Environmental Sciences, University of Munich;*
[2]*Mineralogical State Collection Munich (MSM-SNSB), Munich, Germany.*

Introduction

The Tissint meteorite (fall 2011, S Morocco) was classified as a strongly shocked olivine-phyric shergottite. It is characterized by large olivine grains (up to mm-size) in a fine groundmass of pyroxene and plagioclase (maskelynite) as well as of a number of opaque phases (e.g. ilmenite, chromite, pyrrhotite) [1]. We have reported results of optical microscopy, studies by magnetic and mineralogical means, mainly focused on the phase composition and magnetic/shock signature [2,3]. In our poster we will present new results of detailed and systematic Micro Raman Spectroscopy experiments in order to investigate shock effects and shock introduced high pressure phases within melt veins/pockets in selected large olivine crystals. Peak shocks of 40-45 GPa have been reported earlier from Tissint as determined by Raman Spectroscopy [2,3, see also 11 and refs.]. However, locally much higher peak shocks might have occurred.

The main phases of Tissint Martian meteorite – an olivine-phyric shergottite – can be summarized as follows [1-5, references herein]:
- Olivine megacrysts, ~ Fo81, matrix olivines ~ Fo77
- Clinopyroxene (CPX)
- Plagioclase, all converted to maskelynite (not recrystallized)
- Magnetite (dominating magnetic phase)
- Fe-Ti-Cr oxides
- Fe-sulfides (pyrrhotite, significant Ni content)
- Phosphates (merrilite)

Samples and techniques

A polished section (PS) and several fragments of Tissint were used for our investigations. The preparation and polishing of the PS was done without using any diamond paste or powder, and the PS was not sputtered. Digital optical microscopy (Keyence VHX950F at MSM-SNSB, magnifications up to 2500) allowed to pre-select and pre-investigate in detail best suited olivine megacrystals with shock structures [12]. A Horiba XploRa One LASER Micro Raman microscope (at MSM-SNSB) was used for the 2/3D Raman experiments (mainly high resolution mappings with magnifications up to 1000x, 532 nm LASER).

Results and conclusions

A large number of shock produced phases has been detected and studied in detail, confirming our earlier peak shock determinations of 40-45 GPa. However, locally even higher peak shocks were probably present which produced the very complex phase composition within the melt veins / pockets. In general, this confirms the results of earlier studies by [4-10]. However, our high resolution Raman investigations allowed to study in more detail the 2D/3D distribution of the various shock produced phases. Outstanding and new findings are represented by:
(1) Various types of nano/micro diamonds, most likely CVD diamonds (details under investigation).
(2) Significant concentrations of phases of the (ferro-) periclase (Fe,Mg)O - (magnesio-) wuestite (Mg,Fe)O solid solution: common phases in the melt veins/pockets.
(3) We also found strong indications for the presence of C60 fullerenes within the melt veins / pockets.

The combination of digital optical microscopy (Keyence system) as a first step followed by high resolution LASER Micro Raman Spectroscopy has demonstrated to represent a significant improvement for investigating the phase composition and distribution within mineralogically complex systems [12].

The natural dissociation / conversion of the large olivines to magnesio-wuestite (and perowskite) due to high (impact) shock within olivine-phyric Martian meteorites was reported by [9, 10] and could be confirmed by our investigations. The presence of micro/nano diamonds in Martian meteorites was never observed before to our best knowledge.

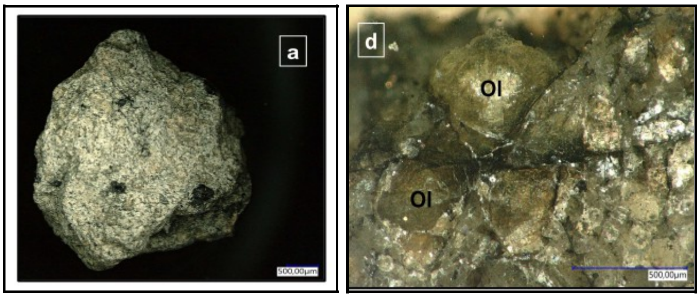

Figure 1: (a) Tissint fragment under study with melt-pockets. (d) Olivine mega-crysts (Ol), in transmitted light with melt veins. Olivines mostly show normal greenish colour.

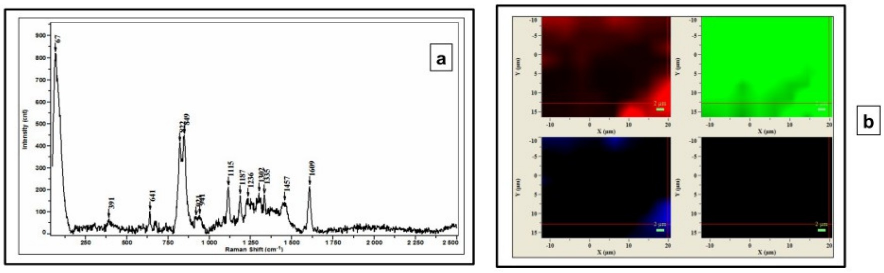

Figure 2: (a) A typical Raman spectrum of one of the investigated areas. Multiple carbon phases could be detected such as graphite (1609), various nano-micro diamonds (1302/1335) and amorphous carbon; and a (ferro-) periclase peak (67). (b) The 2D distribution of: green - olivine matrix; red - graphite; blue - diamond(s). The likely presence of C60 fullerenes is indicated by the (1457) peak.

References

[1] Meteor. Bull. Database, 04/2022;
[2] Hoffmann V., et al., 2012. Asteroids, Comets, Meteorites, #6344.
[3] Hoffmann V. et al., 2013. 35 th Symp. Antarct. Meteor., NIPR/Tokyo.
[4] Balta, J.B., et al., 2015. MAPS, 50(1), 63-85.
[5] Baziotis, I.P., et al., 2013. Nature Communications, 4, 1404.
[6] Chennaoui Aoudjehane, H. et al. , 2012. DOI: 10.1126/science.1224514.
[7] Ma, C., et al., 2016. Geochim. Cosmochim. Acta, 184, 240-256.
[8] Ma, C., et al., 2015. EPSL 422, 194-205.
[9] Miyahara, M., et al., 2012. PNAS 108/15, 5999–6003.
[10] Miyahara, M., et al., 2016. PEPI, 259, 18-28.
[11] Fritz J., et al., 2017. MAPS 52/6, 1216–1232.
[12] Hoffmann V., et al., 2022. Poster, IMA.